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ABSTRACT

This paper is an ethnography of a high school mathematics department that has been struggling with curriculum change since 1977. A literature review of curriculum reform revealed four elements of mathematics reform: (1) a focus on students' complex thinking; (2) a change in locus of authority in the classroom; (3) a change in student roles; and (4) an emphasis on ongoing professional development. These four elements were taken as the focus of this high school mathematics department, either directly or indirectly. This paper describes the following aspects of these four elements: the focus on students' learning to think in complex ways that led teachers to search for materials that used this approach; the negotiation that ensued around the locus of authority, as well as the changes in roles of students and teachers; and finally, the informal, national network of teachers and higher education professionals that was important to the professional development of the teachers. These elements comprised the bulk of the reform efforts at this school. (MKR)

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TEACHER-MADE REFORM: INFLUENCES SHAPING CURRICULUM IN A HIGH SCHOOL MATHEMATICS DEPARTMENT

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Introduction

The nature of curriculum reform in mathematics is a fabric woven with many strands. The goal of this paper is to describe several of those strands from the perspective of those most intimately involved with mathematics education on a day to day basis, teachers and students. This is the tale of a high school mathematics department that has been struggling with curriculum change since 1977, close to twenty years. These teachers began their struggle without the benefit of the current school reform literature. No one handed them a set of cutting edge curricular materials and said, "Here, implement this. It's all ready to go." There was no principal well-versed in the "tribal rhetoric" (Siemon 1989, 266) of school restructuring to lead them through the many steps to effective schools. The motivation to change was theirs, and theirs alone. Throughout this paper, I examine that struggle and ask: what were the forces and influences that drove, shaped and impeded this effort?

A review of the literature in curriculum reform reveals several key elements of mathematics reform. Four of those elements under consideration here are:

1. a focus on student's learning to think in complex ways about mathematical situations (Stephens, Lovitt, Clarke and Romberg 1989; Math Sciences Education Board 1990; NCTM 1991; Anderson et al 1994; Romagnano 1994);
2. a change in the locus of authority held strictly by the teacher to a shared authority between teacher and student (NCTM 1991; Romagnano 1994);
3. a change in the student role from what is considered traditional to an approach "whereby the student negotiates meaning within a learning community, makes connections with past understandings, and builds new understandings within a context" (Anderson et al 1994, 2);
4. an emphasis on "appropriate and ongoing professional development" (NCTM 1991, 3).

These four elements were the focus of this high school mathematics department, directly and indirectly. In this paper I describe the following aspects of these four elements: the focus on student's learning to think in complex ways that led the teachers to search for materials that used this

approach; the negotiation around the locus of authority, as well as the change in the roles of the student and the teacher; and finally, the informal, national network of teachers and higher education professionals that was important to the professional development of the teachers. These elements comprised the bulk of the reform efforts at this school.

Methodology

Ethnographic methodology was used to collect data over a period of six months. These data were in the form of non-participant observations, interviews of students, teachers, administrators, former faculty members and community members, documents from the mathematics department and the school district offices, and artifacts such as exams, student projects, and student journals.

Ethnographic methodology is a qualitative research design that allows the researcher to focus on the sociocultural context of educational phenomena and the meanings that teachers and students bring to that context, in this case curricular reform in high school mathematics. An analysis that rests on ethnographic methodology relies upon the underlying values and beliefs of the group to explain the actions of individuals. "From this perspective meanings and actions, context and situations are inextricably linked and make no sense in isolation from one another. The 'facts' of human activity are social constructions; they exist only by social agreement or consensus among participants in a context and situation" (Eisenhart 1988, 103). It is this social construction of what it meant to reform the teaching and learning of mathematics at Fruitvale High School[1] that this paper will address by examining the actions of individual mathematics teachers and their students in the school context.

Site Selection

Fruitvale (population 55,000) is located in an agricultural region. The demographics of this small city are roughly mirrored in the school population composed of 75% European American, 24% Mexican American, 1% Native American, African American and Asian American. The school hosts 1600 students in grades 9-12. There are ten departments at Fruitvale High School

[1]The name of the school site and names of the teachers throughout this paper are pseudonyms.

and eighty-five persons on the faculty, nine of whom are members of the mathematics department.

Several features of this site drew the attention of the Curriculum Reform Project[2], a research project whose purpose was to document the process of reform in nine schools identified as successful at implementing reform. The unique features of the mathematics department at this site included: several winners of national teaching awards; a tradition of piloting, testing and adopting materials that address mathematics as an integrated body of knowledge and pose complex mathematical situations for students to explore and make sense of; a computer laboratory devoted to a library of mathematics software; the extensive use of graphic calculators at a variety of levels of course offerings; teachers who had searched for funding from grants and other sources within and outside of their district; and a reliance on an informal, teacher-created, national collaborative network for professional development and personal support.

This site was also unique in that the reform efforts were a result of forces within the department of mathematics. Other departments at this high school were relatively traditional, and the principal described himself as a "traditionalist who is uncomfortable with change" (Fieldnote 5-94). Thus, the impetus to change and improve came from individual teachers of mathematics rather than state, district or administrative mandates.

Results and Discussion

This discussion will be initiated by looking at the day-to-day practices that shaped the reform in the mathematics department at Fruitvale High School. These practices included the ongoing drive to acquire materials that focused on mathematical problem solving, the re-negotiation of norms around classroom roles by students and teachers, and the participation by teachers in an informal national support network of mathematics educators. The involvement in these practices sustained the reform efforts at this site, yet at the same time, kept educators suspended in motion. There was no closure; no sense that reform was fully implemented or the job completely done. In this

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[2]The Curriculum Reform Project is funded by the U.S. Department of Education, Office of Educational Research and Improvement, Office of Research, under contract No. RR 91182001.

high school mathematics department, change was a part of the culture. People talked about it, looked for it, and expected it.

Materials

The individuals at this high school began their efforts at curriculum reform when they realized that most students were completing only the minimal mathematics requirements for high school graduation. They felt the sequence of classes and the materials used turned students off to mathematics, particularly the classes that met the basic requirements, referred to as "bonehead math". One teacher, Howard Roseberry, describes the situation in the late 1970's:

> "As you can imagine, bonehead math was pretty boring. We needed to beef up the whole program. We started using calculators, which was unheard of back then, and we disguised skill learning in higher level problems that allowed kids to think, but also to practice their fractions if they needed to practice their fractions" (Interview, 3-94).

These teachers had to put their beliefs about mathematics on the line at a time when a hierarchical sequencing of mathematics classes based on student's ability was the norm. Like most high schools in the late 1970's, the majority of students enrolled in basic math, while a minority of students enrolled in advanced math (Mathematical Sciences Education Board 1990). The teachers at Fruitvale High School saw mathematics as a body of integrated knowledge that all students could learn and they were willing to challenge the district to implement their ideas. Roseberry and one of his colleagues, Ted Wolfe, lobbied the district to reduce class sizes and allow the best math teachers to work with the "low-end" classes. He states:

> "Ted and I worked together to implement our ideas. We convinced the district to let us limit class size to 22. And then we had to argue pretty hard to convince the district that our strongest teachers should be teaching the lowest classes. We had to convince them that the best teachers could explain things in a variety of ways" (Interview 3-94).

At the same time, there was concern that kids who were in the honor's track were entering calculus without the conceptual understanding that they needed to be successful. This concern led to the piloting of pre-calculus materials in 1987 developed by a nationally recognized secondary school, the North Carolina School of Science and Mathematics (NCSSM). Teachers also

persuaded the district to adopt a text book series in 1989 that presented mathematics in an integrated fashion, the University of Chicago School Math Program (UCSMP) materials (Usisken 1990). These materials represented a significant change in the way mathematics were presented, and rested on fundamental beliefs about the purpose of learning mathematics, described in the NCTM standards as "an integrated set of intellectual tools for making sense of mathematical situations" (NCTM 1991, 2).

The teachers in this department were largely influenced by their love of mathematics and their desire to see better materials in the hands of their students. Personal beliefs about mathematics as a system of knowledge, as opposed to a segregated series of topics, and as an approach to problem solving, as opposed to a computational skill, drove them to search for materials that reflected those beliefs, and when materials could not be found, to design their own. Piloting new materials was exciting and transforming. One teacher, Mr. Wolfe, spoke of the personal and professional challenge that he felt in piloting the NCSSM pre-calculus materials (Barret et al 1991).

> "Piloting the North Carolina materials really changed me. I was team teaching with Mr. Davis, and we were holding each other's hand. Teaching these materials made me see math in a different way. I realized it could be done differently" (Interview 3-94).

The years spent on the search for better materials also drove them to search creatively for funding, and they were reasonably successful, resulting in the purchase of state-of-the-art materials and technology. Grants from such sources as Hewlett-Packard, Trout Unlimited, General Telephone and Electric, the State Department of Education, Tech Prep and the Woodrow Wilson Institute were used to buy graphic calculators, computers, televisions, VCRs, tables, chairs, and to pay for travel expenses and conference registration fees.

The personal beliefs that these teachers held about what constituted good mathematics influenced the reform at this site and led them to embrace key components of the current national agenda advancing curriculum reform in mathematics. Such important criteria as the integration of mathematical topics, a substantive use of calculators and computers, student experience with genuine problems, and the exploration and use of real data were in place at this site as early as 1980, criteria that can now be found in numerous

statements on the standards for mathematics education (Mathematical Sciences Education Board 1990; NCTM 1991). As a result of these efforts, the students at this site had the opportunity to interact with interesting mathematical problems in a range of courses offered by the high school. However, this interaction with the materials was limited by the traditional nature of the roles assumed by teachers and students.

Roles

Key to the reform of mathematics curriculum is the shift in the teacher's role from locus of authority and transmitter of knowledge to that of problem poser and manager of the ensuing discussion, with an explicit deflection of the role of teacher as keeper of the knowledge (Anderson et al 1994; Romagnano 1994). This new role assumes a teacher's ability to establish norms of discourse (NCTM 1991) while engaging the students in a verbal and mental exploration of a mathematical problem. Richards (in Von Glaserfeld 1991) describes the nature of traditional classroom discourse as an information transfer in which the subject is presented as a collection of facts. In this traditional setting, because the teacher controls the classroom dynamics, a true mathematical discussion that involves a creative series of spontaneous responses does not occur.

The re-negotiation of norms of discourse to allow for spontaneity, inquiry and discussion was a difficult shift for teachers and students at this site; and the high school context may be particularly resistant to pedagogical change. Talbert and McLaughlin reflect on the conditions that promote "teaching for understanding" in which the teacher acts as a guide in a community of learners who together co-construct knowledge, a description of the classroom that is echoed in the NCTM standards for teaching mathematics (1991).

In their research, Talbert and McLaughlin state that there are many constraints that prevent this model of teaching and learning from occurring, particularly at the high school level, including "the routine character of teaching in high school classrooms, watered down subject matter curriculum, and transmission oriented pedagogy" (Talbert and McLaughlin 1993, 182). High schools have a long tradition of teaching as a transmission of information influenced by the idea that performance on standardized tests is linked to the amount of factual knowledge the student has received from their

teacher. One of the teachers at Fruitvale High School spoke of the students as "a product that we have to put out that has to do well on the SAT for the community" as a reason to avoid too much experimentation with pedagogy (Fieldnote 11).

At Fruitvale High School, student expectations of teachers to act in traditional ways were also a source of constraint to teaching for understanding. Thus, the roles of both teacher and student were being re-negotiated, yet neither had clear ideas about the purpose or structure of the new roles. Romagnano characterizes one type of student response to this re-negotiation as disengagement. In his analysis, the curricular changes called for in the reform of mathematics "substantially changed both the nature and the amount of expectations placed on our students" (Romagnano 1994, 63), resulting in disengagement or resistance on the part of the students. The following vignette describes the negotiation around the changing nature of the teacher-student relationship in the classroom.

Vignette

Students file in to their Algebra class and take their places at one of the nine tables arranged around the large, sunny classroom. The walls are bare except for a string of pictures showing men and women mathematicians throughout history. A student walks in, Sandra, and says to no one in particular but in hearing range of her teacher Mr. Davis, "It's the worst day of my life."

"You always say that," responds Mr. Davis.

"No I don't! I've never said that before," she replies testily.

"It's only nine o'clock in the morning. How can it already be the worst day of your life?" Mr. Davis asks.

"Last night my sister's dog ate my curling iron, so I look like crap. And I'm not speaking to half my friends. Well, two of them."

"You only have four friends?" Mr. Davis is teasing her, as he often does with the students, who seem to enjoy these exchanges with their teacher.

Sandra finishes the conversation saying "It's really bad, O.K.?"

"O.K. people, listen up." This time Mr. Davis is speaking to the entire class. "You only have five days to finish up the chapter. You're going to someone else's class next term, so we have to get you through chapter four by

next Tuesday. [They had spent three weeks outside the text working with codes] I've prepared a summary for you."

Most of the students in this Algebra class are sophomores. The trimester is about to end and they will continue in Algebra, but with a different teacher. Mr. Davis takes a seat at his desk while the kids settle in at their tables, get out their books and begin to work. They talk quietly among themselves. Some read books from other classes. One girl reads Glamour Magazine with a defiant look on her face; most are working in their math books (UCSMP materials). Occasionally someone raises a hand and asks for help. Mr. Davis walks around the class talking quietly with students, checking in on their progress.

Suddenly a student challenges Mr. Davis as he walks by her table. "Why don't you teach us?" It is Sandra. "It's not my responsibility to just sit here and look at this stupid book. You should be teaching us."

Mr. Davis replies, "It's not my responsibility to learn the material. It's your responsibility to learn the material."

Sandra implores him, "But why don't you lecture us? We need you to lecture us."

"I'll lecture you privately right here any time you ask me to. But I'm not going to stand at the chalk board and lecture you. That's not how kids learn best," Mr. Davis answers.

Sandra is not finished. "Yes it is. That is what a teacher is supposed to do. Every teacher stands up and gives a lecture but you."

Another student, Maria, chimes in. "We just do it all by ourselves and there's no help. You say we don't listen anyway when you lecture, but this way is too boring. I don't think I should have to ask for help. You should be able to tell us exactly what we're doing and how to do it."

A third student, Brad, says "You don't make us do anything. We need somebody to push us. And if you don't, I don't do it."

The girl who was reading Glamour magazine adds, "We need a teacher who'll say, 'If you don't get this done by tomorrow, then you'll get a zero. And if you get zeroes for the whole trimester, you'll fail.'"

Mr. Davis is used to these attacks on his teaching style. He describes it as a function of age. "They haven't figured out that they're responsible for their own learning yet." Or he blames himself saying, "I'm not the best teacher. The others are better teachers than I am."

The students were often frustrated by the passive role taken by Davis, but his beliefs about the teacher's role led him to this practice. He believed that lecturing should not be used often as that practice led students to rely on the teacher as keeper of the knowledge. The UCSMP materials required more reading and subsequent analysis of integrated, contextual problems than most algebra texts. Mr. Davis believed that a thorough reading of the text would lead to inquiry and discovery, in effect raising expectations of students to think about mathematics in complex ways and to be responsible for their own learning. However, as he removed himself from the classroom as lecturer, he did not set up an alternative structure. Instead, in the student's mind, he disappeared; the result being student disengagement and resistance. At Fruitvale High School, while informal re-negotiation of roles was ongoing in some classes, more attention was paid to acquiring cutting edge mathematics materials. The changing role of the teacher and of the student was limited by a reliance on the text to transform traditional teacher and student relationships.

Another class that offered a view of this re-negotiation was a course that integrated mathematics and science. This course did not rely on texts or materials; instead it relied heavily on field experiences and created a context for students to initiate their own learning. The students worked in teams of four to gather and analyze data from a nearby stream. These teams were formal cooperative groups, as opposed to the informal groups that worked together as a function of the table arrangements in the other mathematics classrooms. The two teachers of this class, a biologist (Mr. Harmon) and a mathematician (Mr. Cook), saw enrollment in this class as a serious commitment to the group. The kids had an obligation to their teams, to the whole class, to GTE (the grant sponsors) and to the teachers.

Mr. Cook and Mr. Harmon were able to articulate the student's role in the Integrated Science-Math class. Mr. Harmon, the biology teacher, described the cooperative group:

> "Kids in this class are expected to work cooperatively. They don't have the option of joining another group if they don't get along in their group. They have to work it out. It's a formal group. There's always going to be some rubbing, otherwise they're not working close enough. We verbalize to them what their strengths are. We describe the roles within the group to them" (Fieldnote 2-94).

Students understood the goals of this class, and worked together for an entire year to developed a report that would be a source of information for a local conservation group. Several times a week, depending on the weather, students traveled by van to a shallow canyon that encompassed a creek and a hiking trail along side the creek. Each team was responsible for a section of the creek. They collected data from the stream and the surrounding environs and analyzed them, and created a topographic map of the area to answer the research question: is the stream healthy? The following vignette describes an interaction between Mr. Cook and his students in the Integrated Math-Science course.

Vignette

We head out from school in the two vans loaded with gear and kids. The kids are upbeat, excited to be out of the building. They talk and laugh and gently tease each other. They really seem to enjoy going out into the field. We drive west for about 20 minutes to Shale Canyon. An abandoned railroad bed is now a path through the canyon, and the old trestles are foot bridges over the creek. We all get into one van at the trailhead, and make our first stop at a locked gate. The Shale Creek Preservation Society has given the school permission to drive on the trail. One of the kids gets out and unlocks the gate.

We drive to Bridge One and the first team gets out of the van. They will collect water samples that they will test for silica, oxygen, the pH of the stream and other chemical analysis. The teams know exactly where they need to get out and Mr. Cook asks them to direct him to the right spot along the creek. These kids will be on their own for about 45 minutes as they conduct their tests. The rest of the teams get out of the van at about 1/2 mile intervals. Each team has a section of the creek and the canyon they will test and map out.

I go with the last team to the end of the trail. We have an electronic transit and a battery to hook it up to. A friend of Mr. Cook's has donated this equipment to the class. It is worth about $13,000 and offers a very precise measurement of angle, slope, vertical and horizontal distance to assist the kids in mapping the canyon.

There are four students on this team; one girl and three boys, reflecting a mixture of juniors and seniors, as do all the teams. The girl, named Robin, seems to be running the show in a very unassuming way. Two of the boys on this team were the focus of much ribbing as we drove to the site for their

habitual tardiness and absences. It was common knowledge that they both preferred to sleep rather than come to school. They are the one's who must scramble about the steep shale walls of the canyon to place the prism that is the target for the transit. Robin directs their position on the cliffs while her partner Don reads the transit. He asks Robin to check his readings, and she in turn asks Mr. Cook to check her readings of Don's readings. Mr. Cook constantly asks questions about the choices the kids are making in their placement of the prism, the reading of the transit, and their sketching of the site. His questioning does not challenge their positions; it elicits thought and consideration from the students.

"Is that a good spot for the prism?" Robin asks.

Mr. Cook replies, "Well, let's think about it. Where was your last reading?" Robin points to the spot on the cliff that they last took a reading from. "And where do you want to go from here?" She points again. "OK, does that spot make sense?" he asks with a straight and unreadable face.

"I think so," says Robin hesitatingly. While Mr. Cook routinely asks a variety of procedural and conceptual questions of the kids, the kids are often hesitant in their answers. An interview with Robin reveals her thought processes. "My other math classes, you're in a classroom, you have a book, and the teacher tells you what you're doing. You do this step, that step, that step and you get an answer, so it's simpler that way. This way the teacher is trying to make me come up with an answer on my own. They're asking you to think on your own to get the right answers. And then if you make the wrong decision, you have to kind of learn on your own. So that's good, but it's tough that way."

The students in the integrated course were responsible for decisions about data collection, the analysis of the data, and the write-up of the final report. The kids were not entirely comfortable with the raised expectations around their role as team members, but they received guidance and support from their teachers, Mr. Cook and Mr. Harmon, and from other students on their teams, as a part of membership in this community.

The teachers in the integrated course had a conscious agenda that involved team work, discovery learning, and the use of content as it was embedded in context. They were confident that the amount of science and

math that the kids learned would be high, and they were willing to take on a different role to achieve that. Mr. Cook commented on his role as teacher:

> "Teachers are story tellers, and I love to tell the story. But now I think it's better not to tell the story, to let kids figure out what the story is on their own. My experiences in the integrated course have leaked into my other classes. I question more, don't give as many answers. But it's a different course, a different philosophy. I'm looser as a teacher now. It's much easier to be structured, but I don't think kids learn that way" (Fieldnote 2-94).

Thus, membership in the integrated mathematics-science course allowed for a different set of roles and relationships to emerge. The non-traditional setting (the stream site), the non-traditional format (cooperative teams and longer class periods), and the non-traditional curriculum (integration of mathematics and science) became fertile ground for the re-negotiation of roles and a shift in the locus of authority.

In the algebra class described in the first vignette, clues that the format was different were: the teacher no longer lectured to them; they sat at tables in groups of four or five instead of at individual desks; and the mathematical topics were embedded in their text books. These clues did not give the students enough direction to take on new roles, or to allow for a shift in the locus of authority. This teacher knew what he didn't want his math class to look like, but could not easily translate that into what he did want his math class to look like. Little was communicated to the students about the changes made in the curriculum or about new expectations resulting from those changes. When these intentions were articulated clearly, as in the integrated mathematics-science class, the behaviors were more easily negotiated, the roles more easily taken on.

The high school tradition of transmission teaching limited the possibilities for the development of an inquiry based mathematics program. In order for this transmission model to be challenged, the teachers needed more information and guidance. A change in teaching style may be facilitated through professional development. The following section describes one aspect of the professional development of the mathematics teachers at Fruitvale High School, the informal support network, and raises questions about the lack of attention paid to pedagogical content knowledge.

Professional Development

The high school department in a school of this size often functions as an independent community of colleagues (Talbert and McLaughlin 1993). The math department at this site represented the boundaries of this study yet the teachers from the department extended their professional boundaries by joining communities of discourse outside the school. Membership in these extraschool communities influenced the discourse around subject matter knowledge within the department, but had little effect on pedagogical content knowledge.

According to the *Professional Standards for Teaching Mathematics*, professional development should be "appropriate and ongoing" (NCTM 1991, 2). At Fruitvale High School much of the professional development occurred through participation in extraschool communities that developed as a result of the faculty's extensive travel to national conferences out of district and out of state. This travel was funded by grants and award money. Travel to these conferences influenced and inspired teachers to try new things. The relationships that they fostered at these national meetings acted as informal support networks for sustaining the changes at Fruitvale High.

Participation in networks of mathematics educators was important to this department. Teachers enjoyed collaboration and interaction with other teachers in and out of their department, and the network of support that they developed outside of the school was crucial to their continued emphasis on trying new ideas in the classroom.

One teacher, Mrs. Harris, spoke about the inspiration she received from going to other places that were involved in change:

> "I've been fortunate enough to be able to go to some different places where they're really involved in change, in making change. And so what happens with that is then I come back and I feel the need to change for our students. We have a unique department. There are a lot of people that are really open to change. We have very few people that are not really open to change. And most of our people are interested in going to conferences and workshops and have really been involved in their summers in different types of programs. And that as a whole has helped move us along. Whether it's just in applied math or the math-science class or the North Carolina materials, whatever we're doing it's because people have gone out (Interview 11-93).

Upon return from an Applied Math conference, two teachers remarked, "It was like being at an AA [Alcoholics Anonymous] meeting. Everyone was saying 'My name is so-and-so and I teach applied math.' More beneficial than the class was talking with the other teachers. We all had war stories to tell" (Fieldnote 2-94).

Mr. Wolfe remarked that the network of people that he had met while at a national conference and during subsequent follow-up conferences became his support group. Mr. Davis also spoke of a strong involvement with the people he met at national conferences, institutes and training sessions, as well as with a group of writers with whom he worked during the summer months on an applications-based mathematics curriculum.

Teachers encouraged one another to attend conferences and workshops. They found funding for their sojourns from a variety of sources. The local teacher's union bargained with the district for inservice dollars that funded the substitute teachers that the math department relied on to go to conferences and workshops during the school year. The District received state allotted vocational education funds and teachers of Applied Math used these funds to go to conferences. Award winning teachers received money to enhance mathematics at the school and used part of it to assist other teachers in traveling to conferences. Several teachers stated that in one way or another, "you can always find money to go out" (Fieldnote 5-94).

Lieberman and McLaughlin have discussed the importance of subject-area, teacher collaboration. These authors described the networks that teachers participate in, which they contrast with inservice training formats, as more closely aligned with the needs of individual teachers. They stated that: "teachers choose to become active in collegial networks because they afford occasion for professional development and colleagueship and rewards participants with a renewed sense of purpose and efficacy" (Lieberman and McLaughlin 1992, 674). Along with the sense of renewal, the teachers at Fruitvale gained a deepening of content knowledge as well as the social benefits of inclusion in a professional community.

Membership in this national community influenced curricular aspects of the department, but less so pedagogical aspects. The link between what the teachers learned when they traveled to conferences and the improvement of practice was not readily apparent. Returning from a three-day conference on the use of the North Carolina pre-calculus materials, two teachers decided to

use one of the techniques they had read about at the conference. The teachers then successfully allowed students to think and dialogue about, and correct their own quizzes in a pre-calculus class, a practice that engaged the entire class in mathematical discourse. In a conversation after class, they stated that they would probably not use this again. When asked why, one teacher voiced concern that the students would begin to slack off when studying for their quiz, if they knew that they would have a chance to correct it later on. This assessment practice, he believed, would undermine the academic integrity of his students. When pressed to reflect on the evident engagement of the students in their own learning process, the teacher stated, "How are we supposed to figure out these things and still teach 150 students a day?" (Fieldnote 12). He had attempted a new practice and been successful, but was overwhelmed by the idea of thoughtfully integrating it into his daily routine.

The improvement of pedagogical practices is time-consuming, challenging and disruptive. These high school teachers were able to shrug off pedagogical change in favor of the less time consuming and perhaps more interesting (to them) curricular change. This practice was reinforced through participation in extraschool communities of mathematics educators who were content area specialists, not experts in pedagogical reform.

Conclusion

The purpose of this paper was to examine the forces and influences that shaped the mathematics curriculum in a high school mathematics department that was committed to change. The main influence came from a drive to acquire and experiment with materials that focused on the presentation of interesting and complex mathematical problems. This focus led teachers to attend conferences and develop extraschool communities that acted as professional support networks. However, with all the attention focused on subject matter knowledge, pedagogical knowledge was shortchanged.

An examination of the day-to-day practices of teachers and students provided insight into the difficulties around the re-negotiation of roles, a re-negotiation that is seen as essential to the creation of mathematical communities in classrooms. In the traditional classroom setting, the negotiation was characterized by disengagement and resistance by the students, and passivity and frustration on the part of the teacher. In the non-traditional setting of the integrated math-science course, students continued to

rely on teachers for validation of their decisions, but teachers were more willing to relinquish their role as keeper of the knowledge. As a result, negotiation around roles was more fruitful.

Interestingly, teachers traveled to national conferences on reform of school mathematics that included workshops and presentations on pedagogical practices that would allow students to actively participate in mathematical discourse, but those practices were not a consistent part of the reform at this site. This raises questions about why this piece was not more cohesive. The teachers were clearly interested in engaging their students with meaningful and interesting curriculum and materials, but the practice of this engagement did not come easily and seemed to be a source of confusion and frustration in an otherwise well developed high school mathematics program. For the most part, the pedagogical practices were fairly traditional, with occasional experimentation that could be traced to influences outside of the high school. These influences were in the form of journal articles, national and state conferences, and discussions with professional mathematics educators in informal support networks.

The participation in extraschool communities allowed teachers to engage in a national dialogue around questions that were near to their hearts. Their questions focused on the content of high school mathematics: what was appropriate, what was not, how to develop one's own conceptually rich curriculum and where to find curriculum that held interesting problems. These networks were a source of professional esteem and added value to the day to day life of being a high school teacher by allowing the teachers to participate in a community of nationally recognized mathematics educators who were subject matter specialists.

The question that seemed to be missing from their dialogue was how to transform the student role from passive recipient of knowledge, to active learner, discoverer and inquirer within a learning community. This pedagogical piece must be as important to teachers as is the search for interesting mathematical problems. It seems clear that a change in curricular materials alone is insufficient to invoke a change in the epistemology, or the way students and teachers think about mathematics, in schools. Rather, curricular change must facilitate a deep understanding of appropriate pedagogical knowledge linked to subject matter knowledge. The teachers at Fruitvale High School were committed to their subject matter, but thoughtful

implementation of the curriculum in light of the changing role of the student and the teacher did not receive the necessary attention for the creation of a mathematical community.

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